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## **Groundwater thermal-effective injection systems in shallow aquifers: possible alternatives to vertical water wells**

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### **ABSTRACT**

Urbanized areas have environmental features that may influence the development of low-enthalpy geothermal systems and the choice of the most suitable among the available (roughly earth-coupled closed-loop and groundwater open-loop type).

In particular, if compared to less anthropized areas, some characteristic urban elements require particular attention: underground extensive use, contamination of groundwater, interference between the systems, authorization procedures and planning restrictions, the competition with cogeneration systems and the impact on emissions of pollutants.

In this general context, the increasing implementation in several areas of the world of the open-loop groundwater heat pumps technology which discharge into the aquifer for cooling and heating buildings, could potentially cause, even in the short term, a significant environmental impact associated with thermal interference with groundwater, particularly in the shallow aquifers.

The discharge of water at different temperatures compared to baseline (warmer in summer and colder in winter) poses a number of problems in relation to the potential functionality of many existing situations of use of the groundwater (drinking water wells, agricultural, industrial, etc.). In addition, there may be cases of interference between systems, especially in the more densely urbanized areas. Appropriate hydrogeological investigations should be performed for the characterization of the main hydrogeological parameters of the subsoil at the considered site in order to minimize the environmental impact of discharges into aquifers. The current Italian legislation related to withdrawals and discharges into aquifers designs a framework suitable for the protection of groundwater and induce deciding the best configuration of the plant with a case by case approach.

An increased contact area between the dispersant system and the ground makes it possible to affect a greater volume of aquifer and, consequently, reduce the areal extent of the thermal plume that develops around the area of injection minimizing the time and the space needed for the disappearance of the thermal plume and the restoration of undisturbed temperature conditions. The reduction in plan and temporal extension of the thermal plume would have several benefits, minimizing the use of large areas around the buildings involved by the thermal perturbation, with direct implementation benefits.

In order to investigate alternatives to traditional drilled water well for the re-injection and dispersion of water in aquifer downstream of the heat pump, we modeled with FEFLOW the possible reverse use of commercial draining gabions in various types of ground configuration, geometry and interconnection with systems of pre-fabricated vertical drains on a possible reliable test-site. The results highlighted that they can represent a good and efficient alternative for the groundwater dispersion in the aquifers.